

California Environmental Protection Agency



Vapor Recovery Test Procedure

TP-205.2

**Determination of Efficiency of
Phase II Vapor Recovery Systems of
Novel Facilities**

Adopted: April 12, 1996
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**California Environmental Protection Agency
Air Resources Board**

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1 APPLICABILITY

A set of definitions common to all certification and test procedures is in:

**D-200 Definitions for
Certification Procedures and
Test Procedures for
Vapor Recovery Systems**

For the purpose of this procedure, the term "ARB" refers to the State of California Air Resources Board, and the term "ARB Executive Officer" refers to the Executive Officer of the ARB or his or her authorized representative or designate.

1.1 General

This procedure applies to novel vapor recovery systems for controlling gasoline vapors emitted during the dispensing of the fuel into motor vehicles (Phase II). This procedure is only applicable if previously certified vapor recovery equipment (nozzle, hose, P/V valve, etc.) are used with the system. However, if uncertified vapor recovery equipment is used with the system, then such equipment may require prior certification by CP-201.

Small, integral aboveground tank systems shall be tested during the summer months (normally between May and October) when heat transfer rate, solar insolation, and diurnal temperature variation are at a maximum.

Vapor recovery systems are complete systems and shall include all necessary piping, nozzles, couplers, processing units, storage tanks and any other equipment necessary for the control of gasoline vapors during fueling operations. This procedure applies to any vapor emissions associated with the dispensing of any fluid, although it is written to reflect application to the hydrocarbon (HC) vapors associated with the dispensing of gasoline at facilities with balance, hybrid, or assist type vapor recovery systems.

1.2 Modifications

Additional modifications may be required for unique installations. Any modification of this method shall be subject to approval by the ARB Executive Officer.

2 PRINCIPLE AND SUMMARY OF TEST PROCEDURE

2.1 Principle

The purpose of this test procedure is to determine the percent vapor recovery efficiency for a vapor recovery system at a dispensing facility. The percent vapor recovery efficiency is the percent of vapors displaced by dispensing which are recovered by a vapor recovery system rather than emitted to the atmosphere.

This is done by determining the vapor mass flux through four significant areas:

- $m_{(1)}$ = the mass flux through openings at the dispensing interface,
- $m_{(2)}$ = the mass flux through the vapor return line;
- $m_{(3)}$ = the mass flux through the vent and/or the assist processor; and
- $m_{(4)}$ = the mass flux through the vapor incinerator.

In addition to measurements taken during dispensing episodes, the mass flux through test points 3 and 4 shall be measured for at least 12 hours beginning at the end of the last dispensing period. Any emissions measured during this period shall be included in the calculation of Phase II system efficiency.

The percent vapor recovery efficiency is determined as follows:

$$\% \text{ vapor recovery efficiency} = \frac{m_{(2)} - [m_{(3)} + m_{(4)}]}{[m_{(2)} + m_{(1)}]} \times 100\%$$

2.2 Summary

As required to determine an emissions parameter and except where otherwise specified, the equipment and procedures specified in the following test methods shall be used.

EPA Method 2A

EPA Method 2B

EPA Method 18

EPA Method 25A

EPA Method 25B

3 BIASES AND INTERFERENCES

3.1 Static Pressure Performance

Before the performance of all other field data collection for this test procedure, the subject dispensing facility shall demonstrate compliance with the appropriate static pressure performance standard as required by CP-205.

3.2 Non-Conformance with Sleeve Leak Check Requirement

Results for dispensing episodes with leak detector readings (per EPA Method 21) above 10% LEL (2,100 ppm as propane) within one inch (2.5 cm) outside the sampling sleeve shall be reported; but such results shall not be used in the calculation and reporting of final efficiency results.

3.3 Equipment Biases and Interferences

The biases and interferences resulting from the application of these procedures depend on many variables. They depend not only on vehicle operation, facility operation and equipment specifications, but also on uncontrolled seasonal variables, including fuel formulation and ambient temperature and moisture. The equipment required by these procedures has been specified based on data and documentation which show, to the satisfaction of the ARB Executive Officer, satisfactory control of biases and interferences due to the use of the equipment.

Such biases and interferences will vary from one application of these procedures to another due to unanticipated changes in such variables. Alternatives to the required equipment can be as good or better in certain testing circumstances. Such alternatives shall only be used subject to prior written approval by the ARB Executive Officer, as required in § 13.

A primary example of such an alternative is the use of NDIR instead of FID at Test Point 1 for analyzing the sleeve sample. There NDIR can be used based on data and documentation which show, to the satisfaction of the ARB Executive Officer, satisfactory control of biases and interferences due to the use of the equipment.

4 SENSITIVITY, RANGE, AND PRECISION

The measurements of concentration and volumetric parameters required by this test procedure are well within the limits of sensitivity, range, and precision of the specified equipment.

5 EQUIPMENT

Figure 1 of this procedure shows the configuration for testing episodes of dispensing into a 55 gallon drum as a surrogate for a vehicle tank.

Refer to TP-201.2 for details of sleeve sampling. TP-201.2 Figure 1 shows the equipment configuration for testing at the four test points. TP-201.2 Figures 1 through 21 show detail of some instruments and implements. TP-201.2 Figures 6 and 7 show the design of the sampling sleeve for the dispensing area.

5.1 Hydrocarbon Analyzer

The range of any hydrocarbon analyzer shall be selected such that the maximum concentration measured is no more than 90 percent of the range and the average concentration is no less than 10 percent of the range.

Any sampling and analysis system using a non-dispersive infrared detector (NDIR) shall be designed so that 100% of the sample that is extracted for analysis can be returned, unaltered, to the sample manifold.

An analyzer with a NDIR with selected filters to block methane measurement shall be used when the efficiency is to be calculated for non-methane hydrocarbon and when the system under test is small such that extracting a sample for a FID analyzer will affect the system operating parameters. When using a NDIR instrument for total hydrocarbon measurements, a second channel must be present to measure the methane concentration or the instrument filters must be such that total hydrocarbon is measured.

Any sampling and analysis system using a flame ionization detector (FID) can not be designed so that 100% of the sample that is extracted for analysis can be returned, unaltered, to the sample manifold, because the operation of the FID significantly alters the portion of the sample which is analyzed.

An analyzer with a FID may be used for the test when a measurement is for total hydrocarbon and there is no requirement for returning sample, unaltered, to the sample manifold. An important example is the total hydrocarbon measurement on the diluted sample from a test sleeve which has captured transfer emissions from the nozzle fillpipe interface. In this case, the transfer emissions are on their way to the atmosphere normally, so there is no need to return them to a sample manifold.

5.2 Carbon Monoxide Analyzer

Use a NDIR analyzer for measurement of exhaust CO concentrations. To the extent practical, the analyzer range shall be selected such that the maximum concentration measured is no more than 90 percent of the range and the average concentration is no less than 10 percent of the range.

5.3 Carbon Dioxide Analyzer

Use a NDIR analyzer for measurement of exhaust CO₂ concentrations. The analyzer range shall be selected such that the maximum concentration measured is no more than 90 percent of the range and the average concentration is no less than 10 percent of the range.

5.4 Volume

Use a calibrated positive displacement gas volume meter or a turbine meter for measurement of volumetric flow rate.

Use rotary type positive displacement meter(s) with a back pressure limit (BPL) less than:

1.10 inches water column at a flowrate of 3,000 CFH down to
0.05 inches water column at a flowrate of 30 CFH for a meter with a rating over 1000
CFH and

0.70 inches water column at a flowrate of 800 CFH down to
0.04 inches water column at a flowrate of 16 CFH for a meter with a rating of or
under 1000 CFH.

Meter(s) shall be equipped with taps accommodating the following equipment:

(1) taps on the inlet side for

- (a) a thermocouple with a range of 0 to 150 °F and
- (b) a pressure gauge with a range providing absolute pressure readings within 10 to
90% of the range (more than one gauge shall be used, if necessary) and

(2) taps on the inlet and outlet sides for a differential pressure gauge with a range of 0 to
<2x BPL (i.e. full scale shall be less than twice the back pressure limit) or any other
range appropriate to allow detection of a pressure drop greater than the BPL.

5.5 Pressure

Use a pressure measuring device (transducer, inclined manometer or Magnahelic gauge)
with a design range suitable for the pressure being measured. The tap for the pressure
measurement shall be located on the sample coupling attached to the inlet of the volume
meter.

5.6 Temperature

Use a temperature measuring device (thermocouple or mercury in glass thermometer)
with a design range suitable for the temperature being measured. The tap for the
temperature measurement shall be located on the sample coupling attached to the inlet of
the volume meter.

5.7 Other Sampling Implements

The sample schematic (shown in TP-201.2 as Figure 12) requires, in flow order from the
sample manifold:

- (1) a vapor/liquid separator,
- (2) a fine-particulate matter filter,
- (3) a pressure tap,
- (4) an adjustable bypass valve for vapor return to the sample manifold (not necessary for
sleeve sampling), and (5) a rotameter. The sample line shall be of inert material
(teflon is preferred). The sample pump will be a stainless steel bellows type.

5.8 In-line Plumbing

Design goals for plumbing arrangements, regardless of the system being tested, are:

- (1) practically minimize length of vapor line required to reach the volume meter; and

(2) practically minimize pressure drop across in-line plumbing.

5.9 Specific Equipment for Test Point 1 (Nozzle Sleeve)

5.9.1 Sleeve Leak Check Equipment

A volatile organic compound detector which complies with the requirements of EPA Method 21 shall be used.

5.9.2 Sleeve

The sleeve (shown in TP-201.2 as Figures 6 and 7) is designed for vapor sampling at the dispensing area. This design has been tested at 0.005 inches of water column pressure drop at 5 cfm during use in a balance nozzle application.

Other designs may be used which accommodate different dispensing area geometries, subject to the requirement that other designs yield no more pressure drop at five cubic feet per minute (cfm) air flow than the design shown. Compliance with this requirement must be documented in the test report required in the section, "REPORTING RESULTS".

5.9.3 Sleeve Sample Tubing

The sample tube connecting the sleeve to its instrumentation shall be as flexible and lightweight as practical so that the behavior of the nozzle operator is minimally affected by testing activities. It is not necessary to return the unaltered portion of sample flow back to the sample sleeve.

5.9.4 Sleeve Sample Pump

Use a carbon vane pump to minimize contamination of the sample. The pump must be capable of pulling about 5 cfm, but lower flow rates are acceptable provided the sample flow rate is high enough to prevent the sleeve leak check from registering more than 10% LEL (2,100 ppm as propane).

5.10 Equipment for Fuel Dispensing

Actual or simulated fuelings of motor vehicles shall be used to determine the efficiency of the system. Use a stick car or 55 gallon steel drums for simulated vehicle fueling with a vehicle fill pipe permanently attached (welded) to the drum cap. The fill pipe is to have one 1/4 inch stainless steel tube to allow for pressure measurements of the fill spout during filling. Drums shall have a three inch fill cap and a one inch vent plug. A line shall be attached between the 1" vent plug of the drum and the vehicle tank vent line connection on the fillpipe. The drum and fillpipe assembly shall be leak free at normal vapor recovery system pressures.

Also, fueling may be performed into actual vehicle fuel tanks or into stickcars. Stickcars are the plumbing and tank from an actual car with the rest of the car removed.

6 CALIBRATION PROCEDURE

A record of all calibrations shall be maintained.

6.1 Analyzers

Follow the manufacturer's instructions concerning warm-up time and adjustments. On each test day prior to testing, zero the analyzer with a zero gas and span with a known concentration of calibration gas at a level near the highest concentration expected. Perform an intermediate zero and span calibration approximately 2 hours after the initial calibration and at any time a calibration drift is evident. Check for zero and span calibration drift at the end of the test period. All calibrations and adjustments shall be documented.

6.2 Volume Meters

Meters shall be calibrated on an annual basis.

6.3 Pressure Transducers

Calibrate pressure transducers prior to testing and immediately following the test period with a static pressure calibrator for a range of -3 to +3 inches water or appropriate range of operation.

6.4 Temperature Transducers

Calibrate temperature transducers every six months using ambient air, the temperature of which is determined by a NIST traceable mercury-glass thermometer.

7 PRE-TEST PROTOCOL

7.1 Location of Test Site

Prototype systems will be located within 50 miles of Sacramento for testing. Other locations that have meteorology and elevation similar to Sacramento may be accepted at the discretion of the ARB Executive Officer.

7.2 Specification of Test, Challenge, and Failure Modes

The specification of test, challenge, and failure modes such as the number of liquid transfer episodes, volume and volumetric rate of liquid transfer, storage tank volumes, etc. shall be done according to the principles of CP-205 § 5 for the testing and evaluation of vapor recovery equipment. A minimum of 200 gallons of fuel must be dispensed to determine compliance with the performance standards.

7.3 System and Facility Preparation

System equipment and components shall be completely operational and any storage tanks involved in the test shall be filled to the appropriate volume a minimum of 24 hours prior to the scheduled test. The storage tank must be filled to a level between 40 and 60 percent of tank capacity at the start of the Phase II test.

In addition, the system and facility shall be prepared to operate according to any specified test, challenge, and failure modes.

8 TEST PROCEDURE

The facility and system shall be prepared to operate according to any specified test, challenge, and failure modes.

In this section, the term "vent" and the specified procedures for testing vents shall also apply to any assist processor with which such procedures are compatible. Procedures are also specified for incinerator type assist processors. Any assist processor which is incompatible with the application of these procedures shall not be certified until the compatibility requirements of the certification procedures are met.

8.1 Test Locations

Figure 1 illustrates mass flux test locations.

8.1.1 Test Point 1 (Nozzle Sleeve)

8.1.1.1 Sleeve Test Procedure

The sleeve temperature and pressure measurements must be taken from a sample manifold attached to the inlet of the volume meter on the sleeve sampling system. The hydrocarbon sample shall be taken at the exhaust side of the volume meter.

The sleeve must be sampling around all potential vapor leak paths at all times during testing including:

- (1) dispensing periods; and
- (2) "idle nozzle" periods following dispensing periods until the hydrocarbon concentration falls below a concentration of 100 ppm.

The test period for a given fueling shall be from the start of (1) to the end of (2) above.

The sleeve must always be at the fillpipe/nozzle interface for sample collection during dispensing.

Sample at a nominal flow rate of 5 cfm, or less subject to the requirement that the sleeve leak check is less than 10% LEL (2,100 ppm as propane).

8.1.1.2 Sleeve Leak Check Procedure

At least once during each dispensing period and at least once during each following idle nozzle period, readings must be taken with a leak detector per EPA Method 21. If possible, adjust the sleeve so that readings are below 10% LEL (2,100 ppm as propane) within one inch (2.5 cm) outside the sampling sleeve.

8.1.2 Test Point 2 (Vapor Return Line)

The vapor return line sample and temperature and pressure measurements must be taken from a sample manifold attached to the inlet of the volume meter which has been inserted at a break in the vapor return line. The break is usually at the vapor hose connection to the vapor riser. When options are available, the sampling location shall be the shortest practical downstream distance from the nozzle to minimize vapor condensation upstream of the sampling location. Unaltered sample shall be returned to the sample manifold.

8.1.3 Test Point 3 (Vent and/or Assist Processor)

The vent and/or the assist processor sample and temperature and pressure measurements must be taken from a sample manifold attached to the inlet side of the volume meter which has been inserted at a break in the vent line or at the exhaust side of a assist processor. The operation of test equipment shall not interfere with the normal operation of any valve or vent. Unaltered sample shall be returned to the sample manifold.

Data for calculating vent and/or assist processor emissions shall be collected for twelve hours following the last dispensing episode. Any emissions measured during this period shall be included in the calculation of Phase II system efficiency.

8.1.4 Test Point 4 (Vapor Incinerator)

Specific procedures are provided below for testing incinerators due to the complexity of such testing. Other types of assist processors, e.g. adsorbers, are tested by the more conventional hydrocarbon sampling and analytical procedures specified in other sections.

8.1.4.1 Incinerator Performance Specifications

Incinerator emissions shall be determined using the procedures of EPA M-2B, as outlined in this procedure, including any additional requirements provided below.

Any incinerator shall be evaluated and tested to establish:

- (1) a performance specification for hydrocarbon (HC) emissions and
- (2) performance specifications for other critical incinerator operating parameters per CP-201 § 3 which requires, in part:

The results of evaluation and testing of the system, documented in the certification test report, shall include:

- (1) the identification of such critical system operating parameters,
- (2) the performance specifications for such critical system operating parameters, and

- (3) the specification of requirements for indicating gauges, detection devices, and alarms.

Challenge and failure mode testing shall be performed to establish system sensitivity to and performance specifications for the following variables:

- (1) storage tank ullage at start of liquid transfer
- (2) volume and volumetric rate of liquid transfer
- (3) number of nozzles in simultaneous use and
- (4) individual nozzle dispensing rates.

Compliance with the incinerator performance specifications shall be determined per CP-201, as applicable.

8.1.4.2 Incinerator Sampling Parameters

A preliminary evaluation of incinerator operation shall be conducted to assess the rate of change of the magnitude of measured parameters. An appropriate time interval for data recording shall be determined. Such intervals shall be chosen to provide calculated estimates of incinerator mass emissions factors which differ by no more than $\pm 10\%$ from actual, based on engineering judgment.

Data for each parameter shall be collected on such intervals.

Collect and record incinerator data for all of the parameters required to make a determination per EPA M-2B, with additional requirements for auxiliary fuel to expand the applicability of EPA M-2B:

V_{in}	=	total inlet volume entering vapor incinerator (SCF)
$V_{facility}$	=	inlet volume from the facility vapor space (SCF)
V_{fuel}	=	inlet volume of auxiliary fuel (SCF)
V_{out}	=	vapor incinerator outlet volume (SCF)
N	=	number of carbon atoms in each molecule of calibration gas
$[HC]_{facility}$	=	hydrocarbon concentration of inlet volume from the facility vapor space (volume fraction)
$[HC]_{fuel}$	=	hydrocarbon concentration of auxiliary fuel (volume fraction)
$[HC]_{out}$	=	vapor incinerator outlet hydrocarbon concentration (ppm)
$[CO_2]$	=	vapor incinerator outlet carbon dioxide concentration (ppm)
$[CO]$	=	vapor incinerator outlet carbon monoxide concentration (ppm)

Based on an engineering evaluation of a subject incinerator, the ARB Executive Officer may allow simplifying assumptions to be used in place of actual data collection. For example, the volumetric flow rate of auxiliary fuel can often be established from specifications provided by the incinerator manufacturer and the concentration of auxiliary fuel from data available from this section and the fuel supplier.

8.1.4.3 Incinerator Visual Inspection

Visual Inspection. Any visible emissions except for steam, from vapor incinerators are an indication of poor combustion. An incinerator shall not emit air contaminants (not including moisture) in such a manner that the opacity of the emission is greater than 10 percent for a period or periods aggregating more than one minute in any 60 consecutive minutes; or greater than 40 percent opacity at any time. Should such visible emissions from the exhaust be detected, the control system is unacceptable and the problem must be corrected and an application made to the ARB Executive Officer for reconsideration for certification.

8.1.4.4 Incinerator Exhaust Sample Location

The vapor incinerator exhaust sample must be taken from the exhaust stack downstream of the burner far enough to permit complete mixing of the combustion gases. For most sources, this point is at least eight stack diameters downstream of any interference and two diameters upstream of the stack exit. There are many cases where these conditions cannot be met. The sample point shall be no less than one stack diameter from the stack exit and one stack diameter above the high point of the flame and be at a point of maximum velocity head.

In addition to measurements taken during dispensing episodes, The incinerator parameters shall be measured for at least 12 hours beginning at the end of the last dispensing period. Any emissions measured during this period shall be included in the calculation of Phase II system efficiency.

8.1.4.5 Incinerator Inlet Sample Location

The vapor incinerator inlet sample and temperature and pressure measurements must be taken from a sample manifold attached to the inlet side of the volume meter which has been inserted at a break in the inlet line. The installation of test equipment shall not interfere with the normal operation of the vapor incinerator. Unaltered sample shall be returned to the sample manifold.

8.2 General Sampling Parameters

The test team shall collect and record frequent periodic or continuous measurements of the following sample gas variables shown in hexagon outlines in Figure 1:

HC = Hydrocarbon Concentration

CO = Carbon Monoxide Concentration

CO₂ = Carbon Dioxide Concentration

V = Volume

P = Pressure

T = Temperature

8.3 Other Sampling Parameters

Stored Fuel

Temperature

Test Point 1 (Nozzle Sleeve)

Dispensed Fuel Volume

Temperature of gasoline in steel drum

Pressure in fillpipe during simulated fuelings

Test Point 3 (Vent and/or Assist Processor)

Valve Cracking Pressure

8.4 Dispensing Procedure

- (1) Remove cap from fillpipe, insert gasoline dispensing nozzle into fillpipe and lock in place. Push collection sleeve over nozzle/fillpipe interface and assure proper fit.
- (2) Record initial volume, pressure and temperature at the volume meter attached to the interface sleeve collection pump.
- (3) Start interface sleeve collection pump and stop watch simultaneously.
- (4) Dispense 10 to 20 gallons of gasoline at the maximum flowrate. An explosimeter (e.g. TLV) is to be used to monitor outside the sleeve during the fueling episode. Indicate on charts and/or other data print-outs the point at which fueling commences. Leaving the sleeve attached, remove the nozzle from the fillpipe and hang the nozzle on the dispenser. If it is not possible to hang the nozzle with the sleeve attached, it shall be held in a position at the same height and angle as if it were hung on the dispenser. Cap the fillpipe.
- (5) Continue to operate the interface sleeve collection pump for a total of two minutes or until the sleeve concentration has dropped to below 100 ppm, whichever is greater. This is both convenient and provides an adequate period of time to draw the hydrocarbon vapors that may be vented from the nozzle bellows.
- (6) Stop the interface sleeve collection pump and the stopwatch simultaneously. Record the final volume, temperature and pressure at the volume meter and the total pump run

time. The sample pump for the sleeve hydrocarbon analyzer may be stopped when the sleeve collection pump is stopped since the sample extraction may cause the volume meter to continue moving.

- (7) Repeat procedure at 10 to 30 minute intervals until the required throughput has been achieved in order to check the emissions throughout the day.
- (8) The fueling procedure may be used with automobiles or simulated with 55 gallon steel drums as required. Also, fueling may be performed into stickcars. Stickcars are the plumbing and tank from an actual car with the rest of the car removed. When using the steel drums to simulate automobile fuelings, condition each steel drum with 20 gallons of gasoline prior to use of the drum for the simulated fuelings. The steel drums shall be protected from direct sunlight by the use of a canopy.
- (9) Document any incidents of spitback, spillage or premature shutoffs that occur during the fueling episode.

9 QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

9.1 Analyzers

Perform a comprehensive calibration in the laboratory every six months. Check the analyzer with several known concentrations of calibration from reference cylinders to determine linearity.

9.2 Calibration Gases

Calibration gases are classified into three types:

(1) **Standard Reference Materials**

These are **primary standards** to which all other standards shall be traceable. For any substance for which no standard reference material is obtainable, a calibration gas of the highest level of accuracy and precision obtainable shall qualify as a standard reference material, subject to approval by the ARB Executive Officer.

A standard reference material, which normally is kept at a main laboratory, qualifies as an intermediate standard and as a working standard, too.

(2) **Intermediate Standards**

These are **secondary standards** which shall be assayed versus the corresponding NIST-SRM once every six months with a concentration difference which is no more than one percent of the results for the NIST-SRM. An intermediate standard container which does not meet its assay requirement shall be taken out of service. To re-enter service, the intermediate standard container shall be recharged and meet its assay requirement.

An intermediate standard, which normally is kept at a branch laboratory or a shop, qualifies as a working standard, too.

(3) Working Standards

These are **tertiary standards** which shall be assayed versus the corresponding intermediate standard before every test with a concentration difference which is no more than one percent of the results for the intermediate standard. A working standard container which does not meet its assay requirement shall be taken out of service. To re-enter service, the working standard container shall be recharged and meet its assay requirement.

A working standard normally serves for field calibration and testing.

All calibrations shall be performed with a calibration gas of at least working standard quality. Any cylinder is to be recharged or taken out of service when the cylinder pressure drops to 10 percent of the original pressure.

Information on calibration gas containers shall be entered into a permanent log identifying each container by serial number. Sufficient information shall be maintained to allow a determination of the compliance status of each calibration gas per these requirements; such information shall include for each container, but not be limited to each:

- (1) date put in service,
- (2) assay result, and
- (3) date taken out of service.

9.3 Volume Meters

Standard methods and equipment shall be used to calibrate the meters on an annual basis. The calibration curves are to be traceable to NIST standards.

10 RECORDING DATA

Written data records must be kept during testing and kept by chain of custody.

Written data records must contain all information used to calculate and report final results.

These written data records must be kept permanently filed and available for inspection.

The final results must be verifiable by recalculation from the written data records.

11 CALCULATING RESULTS

Note: In addition to other required calculations, vapor recovery system test results shall be calculated in units of pounds of hydrocarbon emitted per thousand gallons of fuel transferred for any results which are expressible in such units.

Calculate all efficiency results to the nearest 0.1%.

In this section, the term "vent" and the specified procedures for calculating results from vent data shall also apply to any assist processor with which such procedures are compatible. Procedures are also specified for incinerator type assist processors. Any assist processor

which is incompatible with the application of these procedures shall not be certified until the compatibility requirements of the certification procedures are met.

11.1 General Nomenclature

Figure 1 illustrates some parameters specified in the calculations.

11.1.1 Parameters

General parameters are listed below, other parameters are defined in the calculations or alternative procedures:

[HC]	=	hydrocarbon concentration (volume fraction),
V_m	=	measured volume of gases and vapors,
P	=	pressure, and
T	=	temperature.

For any dispensing episode:

D	=	volume of liquid dispensed, and
Δt	=	elapsed time of dispensing.

11.1.2 Subscripts

Subscripts shall be used to distinguish parameters and modes of measurement, e.g.:

$P_{(s,e,t)}$	=	value of parameter "P" for subinterval "s" of dispensing episode "e" at test point "t".
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Any or all of these subscripts may modify a parameter, and for consistency, subscripts will appear in the order given above, e.g.:

$P_{(e,t)}$	=	value of parameter "P" for dispensing episode "e" at test point "t"; and
P_t	=	value of parameter "P" for an entire test at test point "t".

11.2 Standardization and Calibration of Parameters

11.2.1 Volume Standardization

Directly measured volumes (such as those directly measured for Test Points 1, 2, and 3) shall be standardized as follows:

$$V = V_m \left(\frac{528}{T} \right) \left(\frac{P_b + \left(\frac{P}{13.6} \right)}{29.92} \right)$$

where:

V = volume corrected to standard conditions (ft^3).

V_m = measured volume (ft^3).

P_b = barometric pressure (in. Hg).

P = differential pressure in sample line (in. water gauge).

T = temperature of gas stream ($^{\circ}\text{R}$).

11.2.2 Concentration

Each measured concentration of gas and vapor shall be corrected for any analyzer zero and/or span drifts and shall be expressed as a volume fraction (i.e. % or ppm).

11.2.3 Mass

Masses shall be calculated from calibration data and measurements as follows:

$$m = \left(\frac{MW}{385} \right) \times [HC] \times V$$

where:

m = mass (lb_m)

MW = molecular weight of calibration gas ($\text{lb}_m/\text{lb-mole}$)

385 = standard volume of one lb-mole at 528°R and 29.92 in. Hg

Note for manual data reduction: In general, $[HC]_{(e,t)}$ will stabilize to a steady value during a dispensing interval. If this is not the case, break $V_{(e,t)}$ into "s" subintervals and calculate:

$$m_{(e,t)} = \left(\frac{MW}{385} \right) \times \sum_1^s ([HC]_{(s,e,t)} \times V_{(s,e,t)})$$

11.3 Volume Calculations

11.3.1 Volume for Test Point 1 (Nozzle Sleeve)

This volume is directly measured and shall be standardized per § 11.2.1.

11.3.2 Volume for Test Point 2 (Vapor Return Line)

This volume is directly measured and shall be standardized per § 11.2.1.

11.3.3 Volume for Test Point 3 (Vent and/or Assist Processor)

This volume is directly measured and shall be standardized per § 11.2.1.

11.3.4 Volume for Test Point 4 (Incinerator)

11.3.4.1 Preliminary Incinerator Outlet Volume Calculations

Note the possibility for simplifying assumptions described in § 8.1.4.2.

Before calculating the vapor incinerator outlet volume, calculate the following preliminary values:

(1) **inlet volume from the facility vapor space**

Any inlet volume from the facility vapor space entering the vapor incinerator is directly measured and shall be standardized per § 11.2.1.

(2) **inlet volume auxiliary fuel**

Any inlet volume from auxiliary fuel entering the vapor incinerator is directly measured and shall be standardized per § 11.2.1.

(3) **total inlet volume entering vapor incinerator**

$$V_{in} = V_{facility} + V_{fuel}$$

where:

$$V_{in} = \text{total inlet volume entering vapor incinerator (SCF)}$$

$$V_{facility} = \text{inlet volume from the facility vapor space (SCF)}$$

$$V_{fuel} = \text{inlet volume of auxiliary fuel (SCF)}$$

(4) **inlet hydrocarbon concentration**

$$[HC]_{in} = \frac{(N[HC]_{facility} V_{facility}) + (N[HC]_{fuel} V_{fuel})}{V_{in}}$$

where:

$[HC]_{in}$	=	inlet hydrocarbon concentration entering vapor incinerator (ppm)
N	=	number of carbon atoms in each molecule of calibration gas
$[HC]_{facility}$	=	hydrocarbon concentration of inlet volume from the facility vapor space (volume fraction)
$[HC]_{fuel}$	=	hydrocarbon concentration of auxiliary fuel (volume fraction)

11.3.4.2 Final Incinerator Outlet Volume Calculations

Calculate any vapor incinerator outlet volume using the following equation:

$$V_{out} = V_{in} \left(\frac{[HC]_{in}}{N[HC]_{out} + [CO_2] + [CO] - 300} \right)$$

where:

V_{out}	=	vapor incinerator outlet volume (SCF)
N	=	number of carbon atoms in each molecule of calibration gas
$[HC]_{out}$	=	vapor incinerator outlet hydrocarbon concentration (ppm)
$[CO_2]$	=	vapor incinerator outlet carbon dioxide concentration (ppm)
$[CO]$	=	vapor incinerator outlet carbon monoxide concentration (ppm)
300	=	assumed background concentration (ppm) of CO_2

11.4 Dispensing Facility Vent Calculations

Vent emissions of HC at a dispensing facility must be apportioned to each dispensing episode on a proportional basis of dispensed volume.

11.4.1 Total Vent Emissions

Total vent emissions for all dispensing episodes:

$$m_3 = \text{HC mass through mass flux area 3 (vent)}$$

If the ARB Executive Officer determines that a portion of m_3 is due to Phase I activity, then m_3 may be diminished by that portion.

11.4.2 Apportioned Vent Emissions

For any D_e :

$f(D_e, m_3)$ = the fraction of vent emissions assigned to each dispensing episode on a proportional basis of dispensed volume.

$$= \frac{(\text{liquid volume dispensed})_i}{(\text{all liquid volume dispensed during flux of } m_3)}$$

$$m_{(e,3)} = m_3 \times f(D_e, m_3)$$

11.5 Individual Dispensing Episode Calculations

Processor and incinerator emissions of HC at a dispensing facility must be apportioned to each dispensing episode on a proportional basis of dispensed volume. Use the same apportionment algorithm as for the vent emissions above.

The term "dispensing episode" is used here to generalize the applicability of these procedures.

Unless otherwise specified by the certification process, a dispensing episode starts with the removal of a nozzle from a dispenser and ends with the start of the next dispensing episode when the nozzle is removed again.

It is assumed that dispensing is into a vehicle fuel tank with a fillpipe test point and a vapor return line test point, but these calculations also apply to, for example, dispensing into surrogate tanks such as 55 gallon drums.

11.5.1 Mass through a Given Test Point

For any dispensing episode:

$$m_{(e,t)} = \text{HC mass through a given test point}$$

11.5.2 Individual Dispensing Episode Calculations

If an engineering evaluation determines that individual dispensing episode efficiencies are necessary to characterize the performance of a system, then each dispensing episode efficiency, E_e , can be calculated from the individual $m_{(e,t)}$:

$$E_e = \frac{m_{(e,2)} - [m_{(e,3)} + m_{(e,4)}]}{[m_{(e,2)} + m_{(e,1)}]} \times 100\%$$

where:

$m_{(e,1)}$ = the mass flux through openings at the dispensing interface,

$m_{(e,2)}$ = the mass flux through the vapor return line;

$m_{(e,3)}$ = the mass flux through the vent and/or the assist processor;
and

$m_{(e,4)}$ = the mass flux through the vapor incinerator.

11.6 Efficiency Test Result Calculation

Note that the two calculations provided below will not necessarily yield the same result.

The calculation of § 11.6.1 shall be used whenever each of the "n" dispensing episodes is a statistically weighted representative of a group of dispensing episodes. This is the case when TP-201.2a is used to determine a matrix of dispensing episodes, each of which is linked to a vehicle which represents a portion of the fleet based on vehicle miles traveled.

The calculation of § 11.6.2 may be used whenever each of the "n" dispensing episodes is not intended to be a statistically weighted representative of a group of dispensing episodes. This approach will fail to characterize the in-use system efficiency unless the performance of a system is the same for every dispensing episode.

For example, consider a first kind of dispensing episode (Case "A" with 92% efficiency) which occurs for 2/3 of all liquid transferred and a second kind of dispensing episode (Case "B" with 98% efficiency) which occurs for 1/3 of all liquid transferred; and assume that all tests are for the same amount of liquid transferred.

Combined with a statistical weighting procedure, such as TP-201.2a, § 11.6.1 would correctly yield 94%, because two tests would be done for Case A and one test would be done for Case B.

Without a statistical weighting procedure, § 11.6.2 would incorrectly yield 95% and result in inappropriate certification of the system at a 95% performance standard.

11.6.1 Calculation Using Individual Dispensing Episode Efficiencies

For the tested vapor recovery equipment, the efficiency test result, E, for this procedure is:

$$E = \sum_{i=1}^n \left(\frac{E_e}{n} \right)$$

where "n" is the number of dispensing episodes.

11.6.2 Calculation Using Test Point Masses

For the tested vapor recovery equipment, the efficiency test result, E, for this procedure can be calculated from the individual $m_{(e,t)}$:

$$E_e = \frac{\sum_1^n m_{(e,2)} - \left[\sum_1^n m_{(e,3)} + \sum_1^n m_{(e,4)} \right]}{\left[\sum_1^n m_{(e,2)} + \sum_1^n m_{(e,1)} \right]} \times 100\%$$

where "n" is the number of dispensing episodes.

12 REPORTING RESULTS

Note: In addition to other required results, vapor recovery system test results shall be reported in units of pounds of hydrocarbon emitted per thousand gallons of fuel transferred for any results which are expressible in such units.

Report all efficiency results to the nearest 1%.

Results shall be reported as specified in CP-205.

13 ALTERNATIVE TEST PROCEDURES

Test procedures, other than specified above, shall only be used if prior written approval is obtained from the ARB Executive Officer. In order to secure the ARB Executive Officer's approval of an alternative test procedure, the applicant is responsible for demonstrating to the ARB Executive Officer's satisfaction that the alternative test procedure is equivalent to this test procedure.

- (1) Such approval shall be granted on a case-by-case basis only. Because of the evolving nature of technology and procedures for vapor recovery systems, such approval shall not be granted in subsequent cases without a new request for approval and a new demonstration of equivalency.
- (2) Documentation of any such approvals, demonstrations, and approvals shall be maintained in the ARB Executive Officer's files and shall be made available upon request.

14 REFERENCES

This section is reserved for future specification.

15 EXAMPLE FIGURES

Figure 1 is a schematic drawing showing some of the test location details for novel facilities.

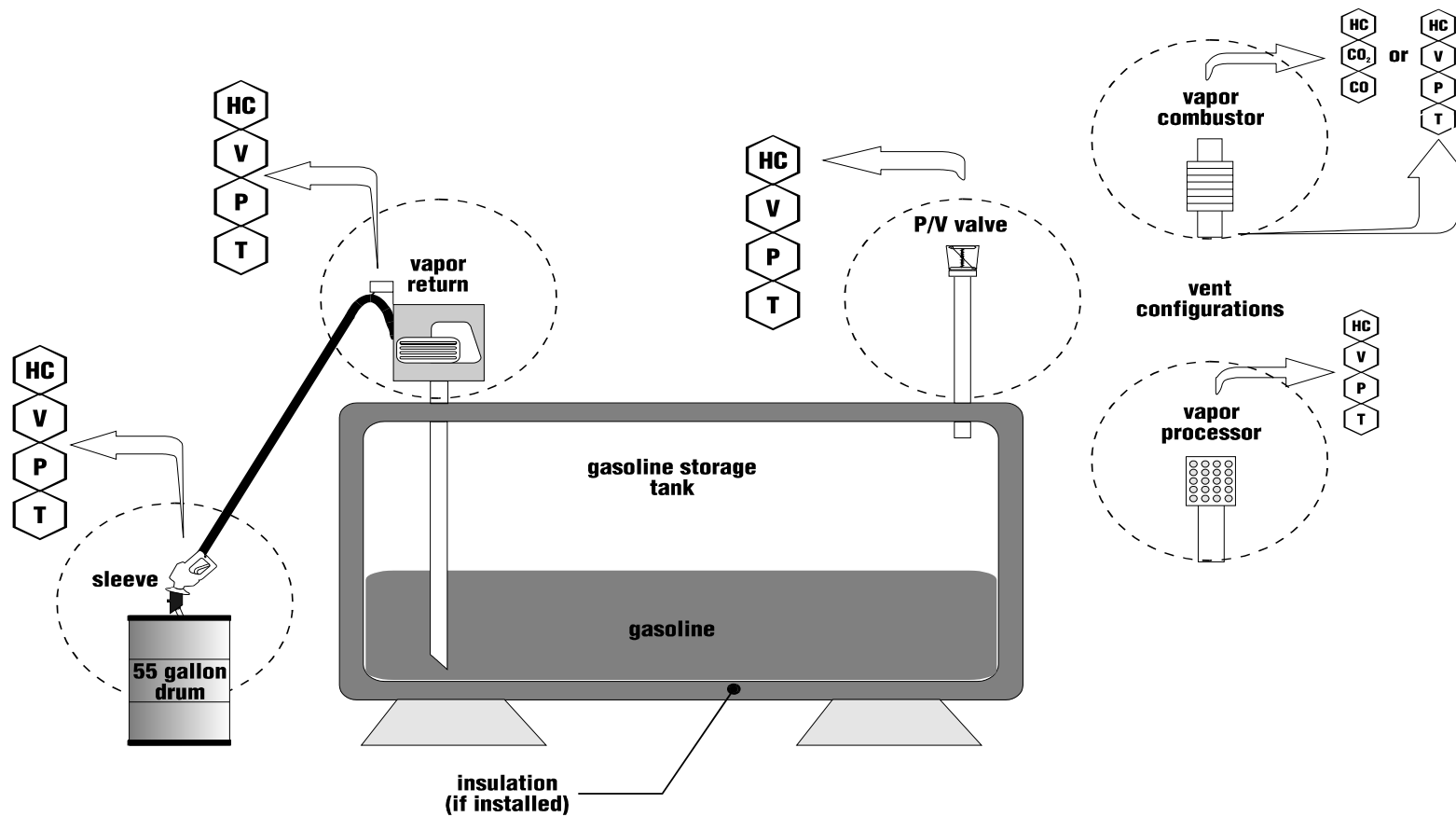
Each figure provides an illustration of an implementation which conforms to the requirements of this test procedure; other implementations which so conform are acceptable, too. Any specifications or dimensions provided in the figures are for example only, unless such specifications or dimensions are provided as requirements in the text of this or some other required test procedure.

Note:

Further procedural details, figures, forms, and tables are provided in the other test procedures; such can be used after appropriate modifications for novel aspects of a tested system have been made, on a case-by-case basis, subsequent to an engineering evaluation.

Figure 1
Test Locations for Novel Facilities

FIGURE 1
Test Locations for Novel Facilities



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